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MARINE BORER CONTROL
PART III
TOXIN DIFFUSION TEST

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ABSTRACT

A study was made at the Naval Research Laboratory on the ability of wood impregnated with creosote to protect adjacent untreated wood against attack by marine borers. This was done by sandwiching panels of untreated wood of varying widths between panels of treated wood and noting the intensity of attack on the untreated area during exposure in the ocean. For comparison, sandwiches were fabricated with wood treated with a copper-base antifouling paint and also with wood treated with a gloss lacquer. Wood impregnated with creosote afforded little protection to adjacent untreated wood; the protection afforded by the copper-base antifouling paint was distinctly superior to that afforded by creosote.

PROBLEM STATUS

This is a final report on one phase of the problem; work is continuing on other phases.

AUTHORIZATION

NRL Problem C03-04
Project NR 603-040

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INTRODUCTION

The problem of protecting submerged wood against attacks by marine borers* is one that has concerned the Navy almost from its inception. Because high-temperature coal-tar creosote is undoubtedly the outstanding preservative in use today for treatment of piling and because, even after more than a century, the preservation of wood by creosote is largely an empirical process, authorization was given the Laboratory to investigate the relationship between the chemical nature of creosote and its protective action against marine borers.

The importance of the toxicity of creosote in relation to its protective action is not generally agreed upon. However, it has now been shown that creosote is extremely toxic to marine borers. Respirometric techniques developed at the Marine Laboratory, University of Miami,[1] have demonstrated that creosote concentrations on the order of 5×10^{-7} g per ml of sea water are uniformly lethal to Teredo larvae and that a response is noted at a concentration between 5×10^{-11} and 10^{-12} g per ml. Other tests have also indicated that creosote-treated wood liberates a soluble toxic substance in sea water. For example, water extracts of creosote were shown to be extremely toxic to marine borer larvae. Futhermore, larvae did not attack untreated slips of wood in the presence of treated slips.[1]

In view of this accumulated evidence, it seems that beyond reasonable doubt, one of the factors in service protection of submarine wood by creosote is a diffusion of the toxins from the creosote in the wood to the surrounding water. To determine whether creosote-treated wood protects adjacent untreated wood by lateral diffusion and if so, to determine the range of this protection, the Marine Laboratory devised a so-called toxic diffusion test. In these experiments, a 1/8-inch wooden veneer, impregnated to 20 lb per cu ft with creosote, was affixed to one side of a wooden panel leaving holidays (unveneered portions) of widths that ranged from 1/8 to 2 inches. The remainder of the panel was completely covered with a nontoxic paint. For comparison a similar set of holiday panels was prepared for each of two varieties of copper-base bottom paint and also for a nontoxic deck paint. It was found that one brand of copper-base paint protected the holidays up to a width of 1 inch and the other to a width of 1/2 inch. The holidays ostensibly protected by cresote, however, were mostly eroded away by Limnoria, thus indicating that lateral protection by creosote was not effective. This was difficult to explain in veiw of the toxicity tests discussed earlier.

At this point, the Naval Research Laboratory, because of its basic interest in creosote and the marine borer problem, joined with the Marine Laboratory at the latter's invitation

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*Part I of this series is published as NRL Report 3940, Part II as NRL Report 4409.

[1] "Semi-Annual Progress Reports of the Marine Laboratory," University of Miami, Coral Gables, Florida, February 1952 - January 1954

in a cooperative study of the toxic diffusion. A new type of holiday panel designed at NRL, it was felt, had the advantage of having only the holidays and treated portions in contact with the water. This report deals with the preparation and testing of these panels along with an interpretation of test results.

EXPERIMENTAL PROCEDURE

For the toxic diffusion tests two varieties of panels were constructed although they were of the same basic design, namely, an untreated piece of wood (holiday) sandwiched between treated pieces.

The first set of sandwich panels (hereinafter referred to simply as sandwiches to distinguish them from the components of the sandwich called holidays and panels) were prepared from clear white pine panels 1-1/2 × 5 inches. The holidays were 1/8, 1/4, and 1/2 inch in width; the 1/4-inch holiday consisted of two 1/8-inch panels. The treated portions of the sandwiches consisted of two 1/2-inch panels on each side of the holiday. Before impregnation, the sandwich was clamped together and two holes drilled through the middle, one hole an inch from each end. After treatment, the sandwich was assembled and held securely together by means of two 3/32-inch bolts inserted through the holes so as to give the effect of a solid block of wood (Fig. 1). The multiplicity of panels composing each sandwich of this first variety was not particularly desirable but was tolerated because the panels were on hand and the experiment could be started without delay.

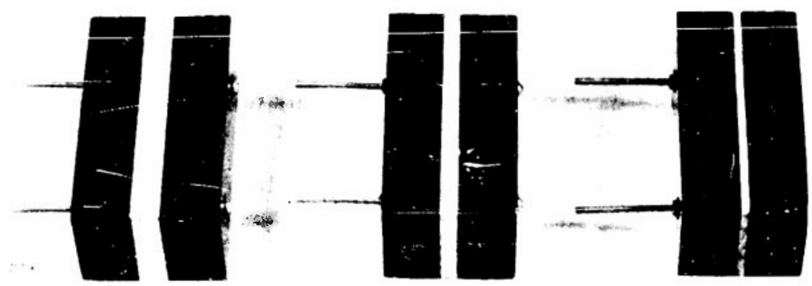

Fig. 1 - Sandwiches fabricated from 5 × 1.5-in. panels

The second variety of sandwich consisted of three panels only and was also fabricated from clear white pine. The treated panels were 7 × 1-1/2 × 1 inches. The holidays, consisting in each case of only one panel, were 1/8, 1/4, 1/2, and 1 inch in width. The sandwiches were bolted together in the same way as the smaller panels.

The 5 × 1/2 × 1/2-inch panels were impregnated with A.W.P.A. Grade 1 creosote to a level of about 30 lb per cu ft by a process essentially similar to the Lowry process. The panels were allowed to bleed to constant weight after impregnation. The 7 × 1-1/2 × 1-inch panels were treated in the same way to refusal. For comparison with creosote, sets of sandwiches were also made up with the treated panels of one set sprayed with a copper-base antifouling paint (Navy 105) and the other with a white lacquer gloss.

The sandwiches were then exposed to marine borer attack in the sea. One exposure took place at the Marine Laboratory, Miami, Florida and another at Fort Amador, Canal Zone

RESULTS

Inspection of Table 1 reveals that after 2 months' exposure there was incipient attack on all the holidays of the creosote and lacquer sandwiches but none on the antifouling paint sandwich. No treated areas had been violated. After 3 months of exposure there was very light attack on the whole lacquer sandwich and on the holidays of the creosote sandwiches; the antifouling sandwiches were still intact. A 6 months' exposure produced heavy attack on the lacquer sandwiches and on all the creosote sandwich holidays.

TABLE 1

Attack Ratings of 5 × 1½-Inch Holiday Panels Exposed November 3, 1952

Exposure (Mo.)	Holiday Thickness (In.)	Panel No.	Attack Rating*																	
			Creosote						Antifouling Paint						Gloss Lacquer					
			Treated			Untreated			Treated			Untreated			Treated			Untreated		
			F†	L‡	T§	F	L	T	F	L	T	F	L	T	F	L	T	F	L	T
2	1/8	1	1	0	0	2	1	0	0	0	0	1	0	0	1	0	0	2	1	1
	1/4	2	1	0	0	2	1	0	0	0	0	1	0	0	1	0	0	2	1	1
	1/2	3	1	0	0	2	1	0	0	0	0	1	0	0	1	0	0	2	1	1
3	1/8	1	2	0	0	0	1	0	0	0	0	0	0	0	1	1	0	1	1	1
	1/4	2	2	0	0	2	1	0	0	0	0	0	0	0	1	1	1	1	1	1
	1/2	3	2	0	0	2	2	1	0	0	0	0	0	0	1	1	1	1	1	1
6	1/8	1	5	0	0	5	4	4	1	0	0	1	0	0	2	4	4	2	5	5
	1/4	2	5	0	0	5	5	5	1	0	0	1	0	0	2	4	4	2	4	4
	1/2	3	5	0	0	5	5	5	1	0	0	1	0	0	2	5	5	2	5	5
9	1/8	1	4	0	0	4	4	4	1	0	0	1	0	0	4	5	5	4	5	5
	1/4	2	4	1	0	4	5	5	1	0	0	1	0	0	4	5	5	4	5	5
	1/2	3	4	1	1	4	5	5	1	0	0	1	0	0	4	5	5	4	5	5
12	1/8	1	Panels Removed						1	1	1	1	0	0	Panels Removed					
	1/4	2							1	1	2	1	0	0						
	1/2	3							1	0	0	1	0	0						

*1 - Very Light Attack
2 - Light Attack
3 - Moderate Attack
4 - Heavy Attack
5 - Very Heavy Attack

†F - Fouling
‡L - Limnoria
§T - Teredo

There was no attack on the antifouling paint sandwich or on the treated panels in the creosote sandwiches. The integrity of the antifouling sandwiches was maintained after 9 months' exposure. This exposure, however, produced incipient attack on the treated panels of the creosote sandwich. Even after 12 months' exposure the antifouling paint maintained complete protection of the holidays but, strangely, allowed a light attack on the treated panels.

The results with the larger sandwiches (Table 2) show that no treatment could protect a 1-inch holiday even for as short a time as 2 months. For this period of time both the creosote and antifouling paint protected the 1/2-inch holidays whereas the gloss lacquer protected only a 1/4-inch holiday. After 4 months' exposure incipient attack was noted on the 1/2-inch holidays of both creosote and antifouling paint sandwiches and on the 1/8-inch holiday of the lacquer sandwich. The 1-inch holidays in all of the sandwiches as well as the 1/2-inch holiday in the lacquer sandwich show about the same order of attack as do the control panels. After 6 months of exposure, the creosote and antifouling paint-treated panels were still protecting the 1/4-inch holidays completely while the attack on the 1/2-inch holidays was not markedly greater than that noted after 4 months' exposure. Both treated and untreated components of the lacquer sandwich showed general attack, and the holidays showed somewhat greater attack than the treated panels. It was not until the inspection after 8 months of exposure that the treated panels in the creosote and antifouling paint sandwiches evidenced a light and about equal attack. The antifouling paint still afforded good protection to the 1/8- and 1/4-inch holidays whereas the creosote afforded only fair protection to the 1/8-inch holiday. The lacquer sandwiches, both treated and untreated areas, were badly and equally attacked. After 12 months of exposure the antifouling paint still gave good protection to holidays up to 1/4 inch whereas protection by creosote was questionable even for the 1/8-inch holiday. The treated areas of the creosote and antifouling paint sandwiches showed about equal evidence of attack by Limnoria; creosote appeared to afford superior protection against Teredo. Surprisingly, as in the smaller sandwiches, the sections of the panels treated with antifouling paint in the larger sandwiches with 1/8- and 1/4-inch holidays showed less resistance to attack than did the holidays.

In summary, it may be said that with the small sandwiches, only the antifouling paint protected the holidays up to 1/2 inch in width for the 12 months of the test. The protection afforded the holidays by the creosoted panels was only slightly better than that afforded by the lacquer. Creosote and antifouling paint afforded about equal protection to treated areas.

With the larger sandwiches, no preservative afforded protection to a 1-inch holiday. The antifouling paint afforded protection to a 1/4-inch holiday 12 months of exposure, the creosote through only 6 months of exposure. Both preservatives afforded definite protection to the 1/2-inch holidays for 6 months. Protection of treated areas by creosote and antifouling paint was essentially identical.

The gloss lacquer appeared to confer protection on treated areas definitely for 2 months and possibly some protection for as long as 6 months. It afforded protection to the 1/8- and 1/4-inch holidays definitely for 2 months and in the case of the larger panels, for possibly as long as 6 months.

CONCLUSIONS

It was concluded from these studies that

1. Creosote-impregnated wood offered little protection to adjacent untreated wood and

2. Wood painted with a copper-base antifouling paint afforded better protection to adjacent untreated wood than did wood impregnated with creosote.

TABLE 2
Attack Ratings of 7 x 1½ Inch Holiday Panels Exposed April 23, 1953

Exposure (Mo.)	Holiday Thickness (In.)	Panel No.	Attack Rating*																				
			Creosote						Antifouling Paint						Gloss Lacquer						Control		
			Treated			Untreated			Treated			Untreated			Treated			Untreated			Untreated		
			†F	‡L	T§	F	L	T	F	L	T	F	L	T	F	L	T	F	L	T	F	L	T
2	1/8	1	1	0	0	2	0	0	0	0	0	1	0	0	3	1	0	3	0	0	3	1	1
	1/8	2	1	0	0	2	0	0	0	0	0	1	0	0	3	0	0	3	0	0			
	1/4	1	1	0	0	2	0	0	0	0	0	1	0	0	3	0	0	3	0	0	3	1	1
	1/4	2	1	0	0	2	0	0	0	0	0	1	0	0	3	0	0	3	0	0			
	1/2	1	1	0	0	2	0	0	0	0	0	1	0	0	3	0	0	3	1	1	3	1	1
	1/2	2	1	0	0	2	0	0	0	0	0	1	0	0	3	0	0	3	2	1			
	1	1	1	0	0	2	2	1	0	0	0	1	2	0	3	0	0	3	1	1	3	2	1
	1	2	1	0	0	2	3	1	0	0	0	1	2	1	3	0	0	3	2	1			
4	1/8	1	2	0	0	3	0	0	0	0	0	1	0	0	4	1	1	4	1	0	4	2	2
	1/8	2	2	0	0	3	0	0	0	0	0	1	0	0	4	0	0	4	0	0			
	1/4	1	2	0	0	3	0	0	0	0	0	1	0	0	4	1	0	4	1	0	4	2	1
	1/4	2	2	0	0	3	0	0	0	0	0	1	0	0	4	1	1	4	1	1			
	1/2	1	2	0	0	3	1	0	0	0	0	1	1	0	4	1	1	4	2	1	4	1	2
	1/2	2	2	0	0	3	0	0	0	0	0	1	1	0	4	1	1	4	3	2			
	1	1	2	0	0	3	2	1	0	0	0	1	2	0	4	0	0	4	1	1	4	2	2
	1	2	2	0	0	3	3	2	0	0	0	1	2	1	4	1	0	4	2	1			
6	1/8	1	2	0	0	3	0	0	0	0	0	1	0	0	4	2	1	4	1	1	5	2	3
	1/8	2	2	0	0	3	0	0	0	0	0	1	0	0	4	0	0	4	0	0			
	1/4	1	2	0	0	3	0	0	0	0	0	1	0	0	4	2	1	4	1	0	5	2	2
	1/4	2	2	0	0	3	0	0	0	0	0	1	0	0	4	1	1	4	1	1			
	1/2	1	2	0	0	3	1	0	0	0	0	2	1	0	4	1	1	4	2	1	5	1	2
	1/2	2	2	0	0	3	0	1	0	0	0	2	1	1	4	1	1	4	4	?			
	1	1	2	0	0	3	3	1	0	0	0	2	2	1	4	0	0	4	1	1	5	3	2
	1	2	2	0	0	3	4	?	0	0	0	2	2	1	4	1	1	4	3	1			
8	1/8	1	1	1	0	2	1	1	0	0	1	1	0	0	2	3	3	2	2	1	2	5	?
	1/8	2	1	1	0	2	2	1	0	1	1	1	0	0	2	3	3	2	3	2			
	1/4	1	1	1	0	2	3	0	0	1	0	1	0	0	2	4	?	2	4	?	2	3	3
	1/4	2	1	2	1	2	3	1	0	2	2	1	1	1	2	4	?	2	4	?			
	1/2	1	1	1	1	2	4	4	0	1	0	1	3	3	2	4	?	2	5	?	2	3	5
	1/2	2	1	1	1	2	3	2	0	0	0	1	3	2	2	3	3	2	5	?			
	1	1	1	1	1	2	4	?	0	1	0	1	4	3	2	3	3	2	3	3	2	3	4
	1	2	1	1	2	2	5	?	0	1	1	1	4	?	2	3	2	2	4	?			
10	1/8	1	1	1	0	1	1	1	1	1	1	1	0	0	1	4	?	1	4	?	Destroyed		
	1/8	2	1	1	1	1	4	?	1	1	1	1	0	0	1	4	?	1	5	?			
	1/4	1	1	2	1	1	4	?	1	1	1	1	0	0	1	5	?	1	5	?	1	4	?
	1/4	2	1	2	1	1	4	?	1	2	3	1	1	1	1	5	?	1	5	?			
	1/2	1	1	2	1	1	5	?	1	1	2	1	5	?	1	5	?	1	5	?	1	4	?
	1/2	2	1	1	1	1	4	?	1	1	0	1	3	2	1	5	?	1	5	?			
	1	1	1	1	1	1	5	5	1	1	1	1	5	5	1	4	?	1	5	?	1	5	?
	1	2	1	2	1	1	5	?	1	1	1	1	5	5	1	4	?	1	5	?			
12	1/8	1	2	1	0	2	2	1	2	2	3	2	0	0	Panels Removed						All Panels Destroyed		
	1/8	2	2	3	1	2	5	?	2	3	3	2	0	0									
	1/4	1	2	3	1	2	5	?	2	2	1	2	0	0									
	1/4	2	2	4	1	2	5	?	2	3	4	2	1	1									
	1/2	1	Removed			23 Feb. 54			Removed			23 Feb. 54											
	1/2	2	2	3	1	2	5	?	2	1	2	2	4	3									
	1	1	Removed			23 Feb. 54			Removed			23 Feb. 54											
	1	2	Removed			23 Feb. 54			Removed			23 Feb. 54											

*1 - Very Light Attack
2 - Light Attack
3 - Moderate Attack
4 - Heavy Attack
5 - Very Heavy Attack
? - Attack Indeterminable

† F - Fouling
‡ L - Limnoria
§ T - Teredo

It appears that there is little effective lateral diffusion of toxins from creosote-impregnated wood along adjacent untreated wood. It may be, as suggested by F. G. W. Smith of the Marine Laboratory, that antifouling paint tends to diffuse along the surface of the wood and thus maintains a fairly high, toxic concentration, whereas toxin from creosote, once released from the wood, may much more rapidly diffuse into the water.

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